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BULLETIN No. 64.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF CHEMISTRY.

THE INFLUENCE OF ENVIRONMENT

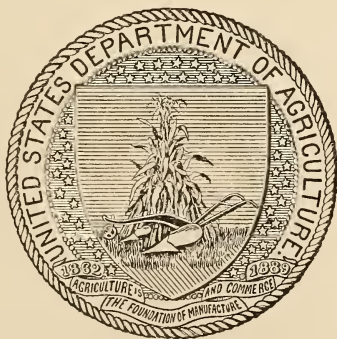
UPON THE

COMPOSITION OF THE SUGAR BEET, 1900.

BY

HARVEY W. WILEY,
CHIEF OF BUREAU,

IN COLLABORATION WITH THE WEATHER BUREAU AND THE AGRICULTURAL
EXPERIMENT STATIONS OF INDIANA, IOWA, KENTUCKY, MICHIGAN,
NEW YORK, CORNELL UNIVERSITY, NORTH CAROLINA,
UTAH, AND WISCONSIN.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., July 30, 1901.

SIR: I have the honor to submit herewith for your inspection and approval manuscript and graphic charts showing the results of the study by the Division of Chemistry, in collaboration with a number of the experiment stations and with the Weather Bureau, of effect of environment upon the chemical composition of the sugar beet. I recommend that this manuscript be printed as Bulletin No. 64, Bureau of Chemistry.

Respectfully,

H. W. WILEY, *Chief of Bureau.*

Hon. JAMES WILSON, *Secretary.*

CONTENTS.

	Page.
Organization of collaborative work	9
Experiments conducted at Washington, D. C.	11
Meteorological data	11
Analytical data	12
Experiments conducted by the Indiana Station.....	12
At Lafayette, Ind.—	
Meteorological data	13
Analytical data	13
At North Judson, Ind.—	
Analytical data	14
Meteorological data	14
Experiments conducted by the Iowa Station	15
Analytical data	15
Meteorological data	15
Experiments conducted by the Kentucky Station.....	16
Meteorological data	16
Analytical data	16
Experiments conducted by the Michigan Station.....	17
Meteorological data	17
Analytical data	18
Experiments conducted by the New York Station at Geneva	18
Meteorological data	19
Analytical data—	
Determined by the Division of Chemistry.....	19
Determined at the Geneva Station.....	19
Experiments conducted by the New York Station at Ithaca	20
Meteorological data	20
Analytical data	20
Experiments conducted by the North Carolina Station.....	20
Analytical data	20
Meteorological data	21
Experiments conducted by the Utah Station	21
Analytical data	21
Meteorological data	22
Discussion of irrigation experiments	22
Experiments conducted by the Wisconsin Station.....	23
Cultural data	23
Analytical data	24
Meteorological data	25
Summary	25
Averages of analytical data	25
Meteorological data	25
Geodetic data	26
Conclusions	30

ILLUSTRATIONS.

	Page.
Chart No. 1. Platted data for per cent of sugar in the beet, latitude of station, and sunshine record	27
Chart No. 2. Platted data for per cent of sugar in the beet, purity of juice, temperature, and average length of day at station.....	28
Chart No. 3. Platted data for per cent of sugar in the beet, altitude of station, and rainfall record	29

THE INFLUENCE OF ENVIRONMENT UPON THE COMPOSITION OF THE SUGAR BEET, 1900.

ORGANIZATION OF COLLABORATIVE WORK.

For more than a quarter of a century the Division of Chemistry of the Department of Agriculture has been studying the effect of environment upon the composition of the sugar beet in so far as its content of sugar is concerned. The present bulletin will be devoted principally to the study of climatic influences, reserving for future monographs the rôles played by the soil and applied fertilizers.

The early studies of this division emphasized the fact, already pointed out by European investigators, that beets grown in more northern latitudes show a higher content of sugar than when grown farther south. So strongly were these facts brought out by our own investigations that it was deemed advisable to limit, or at least suggest the limitation of, the growth of the sugar beet for commercial purposes to the more northern portions of our country. When, later on, the development of the arid regions showed the possibility of the production of beets of high grade, a totally different problem was presented for consideration—a problem which had never been entered upon by investigators of agricultural science. It is evident that the factors which are dominant in irrigated areas are very different from those which determine the character of the product in areas where the rainfall is usually sufficient for the production of the crop. In the present bulletin our studies have been confined to the usual climatic conditions prevalent throughout the greater part of the United States devoted to agriculture. In order, however, to include at least some idea of the nature of the problem in irrigated regions, one station, namely, that of Utah, was invited to collaborate in the work. The Bureau¹ is greatly indebted to the directors of the agricultural experiment stations who consented to collaborate in the work, not only for the heartiness and value of their cooperation, but especially for the reason that this collaboration was given without adequate compensation. Inasmuch as the funds available for the investigation were very limited and scarcely more than sufficient to conduct the chemical work at the Department

¹ On July 1, 1901, the Division of Chemistry became a Bureau.

of Agriculture, it would have been impossible to have carried on the work without the generosity of the collaborating stations. The following agricultural stations were invited to cooperate in the work and all accepted, namely: Indiana, Iowa, Kentucky, Michigan, New York, North Carolina, Utah, and Wisconsin. In New York both the State station at Geneva and the Cornell station at Ithaca were invited to collaborate.

The following letters were sent to the directors of the several stations named on April 4 and 17, 1900:

APRIL 4, 1900.

DEAR SIR: I have just received from Mr. Maurus Deutsch, one of the progressive sugar-beet seed growers of Austria, a small quantity of the very highest grade of sugar-beet seed, of three different varieties of the Austrian Kleinwanzlebener. I should like very much to have this seed planted with the greatest care, cultivated in the highest style of the art, and analyzed at the period of full maturity.

If you can use a small quantity of this seed, say enough to plant an eighth or a fourth of an acre, I shall be very glad to send it on to you, together with a full description of the names, etc.

Please let me hear from you at your earliest convenience in regard to this matter.

Very truly, yours,

H. W. WILEY, *Chemist*.

APRIL 17, 1900.

DEAR SIR: I take pleasure in sending by separate mail the high-grade Austrian beet seed of which I wrote you a short time ago.

The purpose I have in view in asking your collaboration in this matter is to make a careful study of the influence of climate on the character of the beets grown. To this end the seed has been distributed over a wide range of meteorological conditions, and the result of the study will be of the greatest interest.

For this reason I have requested your aid, and would ask you to take every possible care in the growth of these beets. I especially want the seed planted in sufficient quantities to insure a perfect stand. These seeds have not been tested by the division here, because I did not want to wait until that was done, and therefore I would ask you to plant them at the rate of at least 30 pounds per acre, under the most favorable conditions possible. I would also ask you to attend carefully to the cultivation of the beets, and to keep a record of the cultivation data and the meteorological conditions which prevail during the growing season.

For analytical purposes I would be glad if you would send here, from time to time, representative samples of the beets. Mailing facilities will of course be granted you for this purpose. If you have not already the use of the frank of the Department for this purpose, please inform me at the time of harvest and I will send special franks for the transmission of samples through the mails, and also the directions for securing the representative samples desired.

I would like also to have the analyses made at your own laboratory, if you have time to do so.

I thank you most heartily for your consent to enter into this collaborative work, which I trust may prove of advantage to your station.

Very truly, yours,

H. W. WILEY, *Chemist*.

To each of the stations collaborating the requisite quantity of the Austrian Special Kleinwanzlebener beet seed was sent. There was no special reason for the selection of this particular variety of seed other than that it was produced from mother beets which had been selected by analysis on account of their high sugar content. The tendency of such seeds would therefore be to produce beets of uniformly high grade. It is evident that any variation in the quality of the beets grown in different localities from the same seed must be due to the environment, namely, soil, fertilization, culture, and meteorological conditions.

EXPERIMENTS CONDUCTED AT WASHINGTON, D. C.

A plot on the agricultural farm situated on an island, or reclaimed lands, of the Potomac River, lying south of Aqueduct Bridge, was also planted with the Austrian Special Kleinwanzlebener beet seed and subjected to the ordinary careful cultivation necessary for the production of high-grade beets. These lands, being sufficiently fertile, received no fertilizer of any kind. The soil was formed of débris taken from the Potomac River by dredging machines, and therefore it has no geological characteristics. It is a mixture of silt, sand, and organic matter, readily yielding to tillage and forming a fine seed bed. It was prepared by deep plowing, harrowing, and reducing the surface to fine tilth. The roots produced by a previous year's growth when not in cultivation were carefully removed from the soil. The physical condition of the soil at the time of planting was all that could be desired, and the growth of the beets was uniform and luxuriant. The beets were planted on May 5, and thinned to nearly the proper stand about June 15, the thinning being completed about one month later. They were cultivated once a week until July 15. The meteorological data for Washington for the period of growth is as follows:

Meteorological data for Washington, D. C., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May	64.4	4.02	258.0	443.8	58	17	9
June.....	72.2	10.94	244.1	445.9	55	11	9
July.....	78.7	1.25	351.6	453.0	78	18	5
Total	71.8	16.21			63.7	46	23
August	79.6	2.28	334.7	423.2	79	22	5
September.....	73.6	4.61	254.6	373.4	68	15	6
October.....	61.6	1.44	168.7	346.0	49	13	14
Total	71.6	8.33			65.3	50	25
Sum total.....	71.7	24.54			64.50	96	48

The dates of securing samples, the weight of samples obtained, the estimated yield in tons per acre, average weight of the beets har-

vested, the percentage of sugar in the beet, and the purity of the juice are given in the following table:

Analytical and field data on the Austrian Special Kleinwanzlebener beets grown on the experiment farm, Potomac Flats.

Date harvested.	Weight harvested from 5 feet of row.	Estimated tons per acre.	Average weight.	Sugar in the beet.	Purity.
1900.	<i>Lbs. Oz.</i>		<i>Ounces.</i>	<i>Per cent.</i>	
September 19	46 8	13.5	14.6	9.8	.....
September 24	49 2	14.3	17.9	9.3	72.1
October 3	52 5	15.2	16.1	8.7	70.8
October 9	56 7	16.4	15.8	8.4	71.5
October 15	50 14	14.8	17.7	8.4	71.0
October 22	61 3	17.8	19.1	7.9	69.2
October 30	60 2	17.5	19.8	7.6	68.4
November 6	58 8	17.0	17.7	7.9	63.4
November 13	40 11	11.8	13.6	7.8	69.0
November 19	46 6	13.5	17.7	8.6	71.1
November 27	44 7	12.9	20.3	8.1	66.9
December 3			27.8	7.1	66.4
December 11			22.5	8.6	69.0
Average		15.0	18.5	8.3	69.1

As seen by the table, the samples were taken at intervals of from five to seven days, beginning on September 19 and ending on December 11. The samples which were taken on December 3 and 11 were not weighed, nor was there any calculation made of the yield per acre. The average weight of the beets harvested, however, was determined as usual in these two samples. The average data show that the beets weighed 18.5 ounces, had a content of 8.3 per cent of sugar, with a purity of 69.1. The highest content of sugar was found in the beets first harvested, which leads me to believe that had the analyses been commenced at an earlier date, as, for instance, the first of September or the last week in August, a higher content of sugar might have been found. During the latter part of October there was a notable loss in sugar contained in the samples, which, however, was regained in November and continued until the advent of heavy frosts, a little before the middle of December. The variation in the content of sugar in the individual samples from the mean is quite small; the content of sugar having remained almost constant during the whole period of the investigation. The purity coefficients are very low, but probably no lower than would be expected in beets having only a little over 8 per cent of sugar and produced in a soil favorable to rapid and spongy growth. The analytical data show the futility of attempting to grow beets for commercial purposes in such an environment as was afforded by the Department farm.

EXPERIMENTS CONDUCTED BY THE INDIANA STATION.

These experiments were made at two stations, namely, at the agricultural experiment station at Lafayette and at North Judson, in Starke County. Mr. Huston, the chemist of the station, in his report dated November 7, 1900, makes the following statements:

The beets on our own farm, Lafayette, were badly affected by leaf spot. Those at North Judson were much better, but in sugar percentage they did not equal the beets that we have been receiving from North Judson, which were raised from commercial seed. I have asked Mr. Wilson to send me additional samples, which ought to be here in a few days, and we shall continue examining beets on our own farm until the ground freezes. The season has been unusually warm and pleasant; in fact I think a little too warm in this section for beets to ripen. We had no killing frost until after the 1st of November, and we have not yet had a frost hard enough to injure green tomatoes. The ground is fairly moist, so that the beets are probably still growing. This is a very unusual state of circumstances, as our first killing frost is due, on an average, by the 15th of September.

The meteorological data for Lafayette from May to October are as follows:

Meteorological data for Lafayette,¹ Ind., from May to October, 1900.

	Mean tempera- ture.	Precipi- tation.	Clear days.	Cloudy days.
	<i>Degrees.</i>	<i>Inches.</i>		
May.....	64.3	6.89	8	14
June.....	69.8	7.88	2	17
July.....	74.5	5.36	14	3
Total.....	69.5	20.13	24	34
August.....	78.6	4.21	13	7
September.....	69.3	2.75	13	5
October.....	62.2	3.43	14	7
Total.....	70.0	10.39	40	19
Sum total.....	69.75	30.52	64	53

¹ For sunshine data see table for Indianapolis, the nearest station at which sunshine records were kept.

Meteorological data for Indianapolis,¹ Ind., from May to October, 1900.

	Mean tempera- ture.	Precipi- tation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May.....	65.6	6.14	289.7	446.7	65	7	11
June.....	71.0	4.42	241.7	449.0	54	6	9
July.....	75.2	4.10	325.3	455.2	71	14	4
Total.....	70.6	14.66	.....	.....	63.3	27	24
August.....	79.4	3.32	309.5	425.2	73	9	4
September.....	70.8	2.95	220.8	373.6	59	10	7
October.....	63.4	3.20	226.1	344.9	66	15	7
Total.....	71.2	9.47	.....	.....	66.0	34	18
Sum total.....	70.9	24.13	.....	.....	64.65	61	42

¹ Fifty-nine miles southeast of Lafayette.

One analysis was made of the beets grown at the experiment station, with the following results:

Date of planting.....	May 7
Date of harvesting.....	October 29
Average weight.....	ounces.. 4.9
Sugar in juice.....	per cent.. 10.5
Sugar in beet.....	do..... 9.9
Purity.....	83.0

Two analyses were made of the beets grown by J. M. Wilson at North Judson, giving the following results:

Field data and analyses for Austrian Special Kleinwanzlebener grown at North Judson, Ind.

No.	Date of planting.	Date of harvest.	Average weight.	Sugar in juice.	Sugar in beet.	Purity.
			<i>Ounces.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
1	May 26.....	Oct. 1.....	17.5	13.7	13.0	86.0
2	May 26.....	Oct. 24.....	12.9	15.1	14.3	93.0

The only meteorological data obtainable for North Judson are those for South Bend, as given below, and as no regular station, either agricultural or meteorological, exists at these points, the results for North Judson have not been included in the data platted on the charts.

Meteorological data for North Judson,¹ Ind., from May to October, 1900.

Month.	Mean temperature.	Precipitation.
	<i>Degrees.</i>	<i>Inches.</i>
May.....	62.9	1.74
June.....	69.0	2.66
July.....	72.6	5.81
Total.....	68.2	10.21
August.....	76.4	6.43
September.....	67.4	2.25
October.....	61.4	1.31
Total.....	68.4	9.99
Sum total.....	68.3	20.20

¹ Data given is for South Bend, 40 miles northeast of North Judson. For sunshine record see Lafayette, 58 miles south, and Indianapolis, about 100 miles south, of North Judson.

In transmitting the above meteorological data Mr. Huston, under date of March 27, 1901, makes the following comments:

I inclose the weather record for Lafayette and for South Bend. We have no observer at North Judson, but South Bend is up the valley a little ways, and is practically on the same isotherm. You will notice that the season was quite abnormal at both places, and especially is this true of part of the season during which time the beets ought to ripen; and the number of cloudy days is unusually high. While the rainfall during September and October in the northern part of the State is somewhat below normal, the excessively high temperature in October, together with the fact that nearly all of the rainfall occurred on October 6 and 7, which furnished plenty of water to keep the beets growing, made the ripening period even less favorable than the record would seem to indicate.

It will be observed that the beets grown at North Judson, although somewhat small, were of fair sugar content and of high purity. The beets grown at the experiment station farm were phenomenally small and contained a low percentage of sugar, but a purity slightly above the minimum standard desirable for manufacturing purposes. It is remarkable to see so great a difference in the composition of beets grown in the same State and in localities less than 100 miles apart. North Judson is almost exactly north of Lafayette, and its proximity to Lake Michigan doubtless accounts for the differences in the meteorological environment of the two places. The experience of former

years in the same localities shows that Starke County, in which North Judson is situated, is favorably located for the production of beets of high grade.

EXPERIMENTS CONDUCTED BY THE IOWA STATION.

The sample of Austrian Special Kleinwanzlebener was planted on May 29 in rows 16 inches apart, and thinned on June 20. The plot received the usual careful cultivation. The assistant in agriculture at the Iowa station at Ames, Mr. Atkinson, gives the following description of the soil on which the experiments were made:

The soil upon which the Austrian Special Kleinwanzlebener were grown was an upland prairie. It was a clover sod in 1898; in 1899 it grew a crop of spring wheat, while the beets were grown on it in 1900. It has been several years since it received an application of manure.

The samples were harvested on November 6, and eight beets were sent to the Department of Agriculture, and were analyzed on November 12 with the following results:

Average weight	ounces...	13
Sugar in the beet	per cent...	11.7
Purity		76.9

The season was not considered a favorable one for beet culture. The climatic conditions prevailing during the growing season are shown in the accompanying tables:

Meteorological data for Ames, Iowa,¹ from May to October, 1900.

Month.	Mean temper- ature.	Precipi- tation.	Clear days.	Cloudy days.
	<i>Degrees.</i>	<i>Inches.</i>		
May	64.4	4.36	14	5
June	69.4	6.48	19	1
July	73.0	9.14	12	0
Total	68.9	19.98	45	6
August	76.8	5.46	16	0
September	66.0	7.12	11	1
October	59.8	3.73	17	4
Total	67.5	16.31	44	5
Sum total	68.2	36.29	89	11

¹ For sunshine record see table for Des Moines, that being the nearest station at which a sunshine record was kept.

Meteorological data for Des Moines, Iowa,¹ from May to October, 1900.

Month.	Mean temper- ature.	Precipi- tation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May	64.2	4.76	274.6	451.9	61.0	9	6
June	70.1	4.89	339.3	456.2	74.0	12	2
July	74.2	5.15	300.1	461.8	65.0	11	5
Total	69.5	14.80			66.7	32	13
August	77.7	8.02	278.8	429.4	65.0	11	4
September	65.4	3.66	203.1	374.5	54.0	10	12
October	60.4	3.08	195.7	342.5	57.0	10	9
Total	67.8	14.76			58.7	31	25
Sum total	68.65	29.56			62.7	63	38

¹ Thirty miles south of Ames.

EXPERIMENTS CONDUCTED BY THE KENTUCKY STATION.

The Austrian Special Kleinwanzlebener was planted April 25 in rows 18 inches apart, and was thinned May 22. The soil was a rich loam, and the estimated yield per acre was 10 tons. The season was reported as being favorable, the climatic conditions for the period of growth having been as follows:

Meteorological data for Lexington, Ky., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May	65.6	3.54	297.6	441.7	67.00	15	7
June	72.5	2.19	291.6	443.1	66.00	4	7
July	77.0	2.80	358.4	450.1	80.00	15	3
Total	71.7	8.53	.....	.....	71.00	34	17
August	79.3	5.75	361.8	422.1	87.00	8	2
September	73.2	1.85	292.1	373.0	78.00	11	4
October	64.9	.79	243.5	347.3	70.00	15	5
Total	72.5	8.39	.....	.....	78.30	34	11
Sum total	72.1	16.92	.....	.....	74.65	68	28

The analyses were commenced by the station on August 30, and continued at intervals until October 16. After that time the analyses were suspended until November 19, when an additional sample was examined, nine series of analyses having been made altogether.

The results of these analyses were as follows.

Station analyses of Austrian Special Kleinwanzlebener grown at Lexington, Ky.

Date of sampling.	Number of beets taken.	Weight topped.	Weight trimmed.	Brix.	Sugar by polarization.	Sugar in beet.	Purity.
1900.		<i>Ounces.</i>	<i>Ounces.</i>	<i>Degrees.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
August 30	2	11½	8	12.7	10.05	9.6	79.20
September 19	1	20¾	15½	11.2	8.40	8.0	74.10
Do.	1	13½	10	10.0	7.00	6.6	70.00
September 26	2	8¾	5¾	10.2	6.85	6.6	67.72
October 6	1	14¾	11	13.3	9.90	9.4	74.40
Do.	1	9¾	6¾	11.9	8.50	8.1	72.20
October 12	1	12½	7½	10.7	7.35	7.0	68.70
October 16	1	10½	8½	11.9	8.05	7.7	67.60
November 19 .....	.....	10½	8½	13.7	7.00	6.6	65.20
Average .....	.....	12.47	9	11.73	8.12	7.7	71.01

A sample of these beets was sent to the Department of Agriculture for analysis on November 19. In forwarding this sample Dr. Peter, chemist of the station, calls attention to the fact that his analyses show that the beets deteriorated greatly after August. The data obtained by the analysis of the sample sent to the Department of Agriculture were as follows:

Average weight of the beets	ounces..	9
Percentage of sugar in the beets	per cent..	7.9
Purity		68.0

The data show that in the analysis of these samples at the Department of Agriculture a somewhat higher percentage of sugar, of a slightly increased purity, was obtained than that given for the samples taken on the same date, November 19, and analyzed at the Kentucky station. A part of the increase in sugar may be ascribed to the drying out of the samples in transit.

EXPERIMENTS CONDUCTED BY THE MICHIGAN STATION.

A field of sandy loam, selected for this experiment, was subsoiled about ten days before sowing the beet seed, and the surface of the field reduced to a proper degree of tilth. The seeding was done on April 28, 1900, and the beets received the usual cultivation to keep the surface of the soil loose and free from weeds.

The agriculturist of the station, Mr. B. D. Towar, reports:

We are very well pleased with the results, as the ground was by no means the most desirable for growing beets. A good season has been favorable to Michigan beets and satisfactory reports are coming from all directions.

The meteorological conditions are shown by the following data:

Meteorological data for Agricultural College, Mich.,¹ from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	<i>Degrees.</i>	<i>Inches.</i>		
May.....	58.8	4.17	10	9
June.....	65.2	2.57	16	6
July.....	69.6	4.15	13	6
Total.....	64.5	10.89	39	21
August.....	73.3	2.98	12	3
September.....	63.2	.89	16	8
October.....	56.6	2.77	14	8
Total.....	64.4	6.64	42	19
Sum total.....	64.45	17.53	81	40

¹ For sunshine record see table for Detroit, the nearest station at which this record is kept.

Meteorological data for Detroit, Mich.,¹ from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May.....	60.0	3.08	246.5	451.9	55	6	13
June.....	66.6	3.99	310.6	456.2	68	12	6
July.....	72.0	3.71	267.6	461.8	58	9	7
Total.....	66.2	10.78			60.3	27	26
August.....	75.5	2.08	263.3	429.4	61	12	7
September.....	66.8	1.88	215.2	374.5	57	10	5
October.....	60.0	2.85	191.0	342.5	56	12	6
Total.....	67.4	6.81			58	34	18
Sum total.....	66.8	17.59			59.15	61	44

¹ Seventy-six miles southeast of Agricultural College.

Analytical data obtained with the Austrian Special Kleinwanzlebener at the Michigan station.

Number of sample.	Seed test from 100 seed bulbs.			Average distance apart in row.	Yield per acre.	Average weight samples analyzed.	Per cent of sugar in juice.	Per cent of sugar in beet.	Purity.
	Number of sprouts at the end of one week.	Number of sprouts at the end of two weeks.	Seed balls that did not grow.						
1.....	122	150	30	<i>Inches.</i> 6+	<i>Tons.</i> 15.21	<i>Pounds.</i> 12	13.61	12.9	79.27
2.....	135	175	25	6—	16.29	12	14.03	13.3	80.77
Total ..	.....	.....	.....	.....	31.50	24	27.64	26.2	160.04
Average ..	.....	.....	.....	.....	15.75	12	13.82	13.1	80.02

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT GENEVA.

The report of the collaborative work done at the Geneva station was made by the agriculturist, Mr. G. W. Churchill, under date of December 7, 1900. Twelve different plots of beets were grown, of which numbers 3, 6, 9, 12, and 13 were of the Austrian Special Kleinwanzlebener. Plot No. 13 was composed of check rows planted between plots which were fertilized with different materials in order that there should be no extension of the effect of the fertilizers from one plot to another. Under date of December 19 Director Jordan, of the station, made the following report:

For three years we have been making an effort to compare the effect of commercial fertilizers with that of farm manures upon the composition of sugar beets. In all of these years the percentage of sugar and the coefficient of purity with the beets raised on the farm manure have been of a high standard, the percentage of sugar in two years being higher than where the beets received commercial fertilizers. The other year the percentage of sugar was higher in the beets fertilized with farm manure than where no farm manure at all was used. The amount of manure per acre was 40,000 pounds, or about 10 cords. It was manure from the cow stable which had been somewhat fermented but not very fully. In other years we have used fresh manure. I am now working up the results for the three years to publish in a bulletin. I am inclined to think that we have all the time been placing altogether too much confidence in German results as applied to American conditions.

The following table gives the mean temperatures and precipitations for Lyons, 13 miles north of Geneva, during the growing season, the sunshine data not being obtainable for this or any other station nearer than Ithaca, for which place a full set of data may be found further on.

Meteorological data for Lyons, N. Y., from May to October, 1900.

Month.	Mean temperature.	Precipitation.
	Degrees.	Inches.
May	58.4	1.85
June	67.9	2.74
July	72.4	3.46
Total.....	66.2	8.05
August	73.8	2.49
September	67.1	2.01
October	58.6	3.71
Total.....	66.5	8.21
Sum total	66.4	16.26

The samples sent to us by the Geneva station were analyzed in the Division of Chemistry, and the results obtained with the Austrian Special Kleinwanzlebener were as follows:

Department analysis of Austrian Special Kleinwanzlebener beets grown at Geneva, N. Y.

Number.	Weight.	Sugar in juice.	Sugar in beet.	Purity.
	Pounds.	Per cent.	Per cent.	
1	17	15.2	14.4	82.2
2	17	16.0	15.2	83.8
3	17	16.4	15.6	82.8
4	16	16.1	15.3	84.3
5	17	15.2	14.4	82.2
Average.....	16.8	15.78	14.98	83.06

In the above data the samples represented by Nos. 1 and 2 were grown under a heavy fertilization of superphosphate. Nos. 3 and 4, corresponding to Nos. 9 and 12 referred to above, were grown under fertilization with farmyard manure, and No. 5, corresponding to No. 13, represents the check rows planted between the fertilized plots.

A complete study of the sugar content of the beets grown at the Geneva station was made at that place between the dates of November 23 and December 6. The results of these determinations are given in the following table:

Austrian Special Kleinwanzlebener beets.

[Grown and analyzed at the New York Experiment Station, Geneva, N. Y.]

Date of analysis.	Number of plat.	Number of beets used for analysis.	Degree Brix.	Average weight of beets (without tops).	Sugar in juice.	Sugar in beet.	Coefficient of purity.
1900.				Pounds.	Per cent.	Per cent.	
November 23	8	20	19.8	0.97	16.8	16.0	84.8
November 24	8	20	20.7	.965	17.6	16.7	85.2
November 23	9	20	18.8	.95	15.7	14.9	83.7
November 24	9	20	18.6	1.00	15.7	14.9	84.3
November 23	10	20	19.4	.82	16.6	15.8	85.4
December 1	10	20	19.7	.89	17.1	16.3	87.0
November 23 ¹	11	20	22.1	.79	18.5	17.6	84.0
December 4	11	20	20.9	.91	17.5	16.6	83.9
November 23	12	20	19.0	1.63	16.1	15.3	84.7
December 1 ¹	12	20	18.9	.89	16.1	15.3	85.3
December 4	Check.	20	20.9	.76	17.5	16.6	83.6
December 6	Check.	12	19.0	.88	16.2	15.4	85.1
Average			19.8	2.95	16.8	16.0	84.8

¹ Beets somewhat wilted.

² Equivalent to 15.2 ounces.

EXPERIMENTS CONDUCTED BY THE NEW YORK STATION AT ITHACA.

Director I. P. Roberts, of the Ithaca station, reported under date of March 11, 1901, that the Austrian Special Kleinwanzlebener beet seed for the collaborative experiments had been planted on May 17, 1900, in rows 20 inches apart, and harvested on October 26. The soil was a sandy loam in a good state of fertility. The record of the climatic conditions during the growing season is as follows:

Meteorological data for Ithaca, N. Y., for May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	Degrees.	Inches.	Hours.	Hours.			
May	57.1	1.51	281.9	451.9	62	11	15
June	67.0	1.98	242.1	456.2	75	7	12
July	72.0	2.41	332.1	461.8	72	3	11
Total	65.4	5.90	314.8	429.4	69.7	21	38
August	72.3	2.93	260.4	374.5	73	9	8
September	64.9	.94	216.0	342.5	70	11	9
October	57.2	4.06			63	9	13
Total	64.8	7.93			68.7	29	30
Sum total	65.1	18.83			69.2	50	68

The analytical data obtained at the station on the beets raised were as follows:

Average weight of beets analyzed	ounces..	18
Yield per acre	tons..	15
Sugar in the juice	per cent..	14.8
Sugar in the beet	do..	14.0
Coefficient of purity		81.9

EXPERIMENTS CONDUCTED BY THE NORTH CAROLINA STATION.

The seed of the Austrian Special Kleinwanzlebener were planted on May 22, the date of thinning was June 15, and the date of harvesting November 1. The soil was a sandy loam, and the width between the rows 36 inches. The season was rather dry and to that extent unfavorable. The estimated yield per acre was $1\frac{1}{4}$ tons.

Samples of the beets were forwarded to this Department from Raleigh on November 21. They were, however, in such a poor condition when received that they were deemed worthless for analytical purposes and the analytical data are confined therefore to the analyses made at the station at Raleigh. The figures obtained are as follows:

Average weight of beets	ounces..	12.4
Average sugar in the beets	per cent..	5.2

The above data show that the beets were remarkably poor even for the locality. While it was not expected that they would show a

high quantity of sucrose, it is evident that under other conditions or in other seasons a much better result could be obtained. The following table shows the meteorological conditions under which these beets were grown:

Meteorological data for Raleigh, N. C., from May to October, 1900.

Month.	Mean tempera- ture.	Precipi- tation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May	69	3.12	335.1	436.1	77	16	3
June.....	76	8.47	284.9	437.2	65	9	7
July.....	80.9	5.53	313.5	444.3	71	16	4
Total	75.3	17.12			71	41	14
August	82.2	4.51	357.4	418.7	85	25	1
September.....	75.8	2.13	316.5	372.2	85	20	1
October.....	65.6	1.04	208	348.9	60	14	8
Total	74.5	7.68			76.7	59	10
Sum total.....	74.9	24.80			73.9	100	24

EXPERIMENTS CONDUCTED BY THE UTAH STATION.

The data from the Utah Agricultural Experiment Station are included in this report not so much for the purpose of direct comparison as to show the influence of irrigation upon the yield and character of the beets. It is evident that the artificial conditions which obtain in irrigated regions are so different from those that naturally exist as to render of doubtful value a comparison between the two sets of data, and hence the results in Utah have not been included in the graphic charts. It is proposed at some future time to make an additional study in irrigated regions of the influences of sunshine and the differences of latitude on the character of the beets grown under irrigation. Nevertheless there will be some interest attached to the utilization of the data from Utah in the present comparison.

The beets were planted on May 8, the date of thinning was June 7, the dates of irrigation, June 22, July 14 and 28, August 11, and September 1; the dates of cultivation were June 20 and 25, July 16, August 2 and 14; the dates of harvesting were October 24, 25, and 27.

The yield per acre and the analytical results as determined at the Logan station are as follows:

Estimated yield per acre.....	tons..	18.9
Percentage of sugar in the beet	per cent..	12.1
Purity coefficient.....		84.2

The climatic conditions under which these beets were grown are shown in the following tables of data for Logan and Salt Lake City, Utah:

Meteorological data for Logan, Utah,¹ from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days. ²	Cloudy days. ²
	<i>Degrees.</i>	<i>Inches.</i>		
May.....	57.4	1.42	17	11
June.....	70.4	.19	25	3
July.....	70.9	.51	26	3
Total.....	66.2	2.12	68	17
August.....	69.4	.71	24	3
September.....	59.9	.94	20	6
October.....	49.8	2.38	26	2
Total.....	59.7	4.03	70	11
Sum total.....	62.95	6.15	138	28

¹ For sunshine data see table for Salt Lake City, the nearest point at which this record was kept.

² These figures are for Corinne, 19 miles southwest of Logan.

Meteorological data for Salt Lake City, Utah,¹ from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Per cent.		
	<i>Degrees.</i>	<i>Inches.</i>	<i>Hours.</i>	<i>Hours.</i>			
May.....	60.6	0.44	356.5	449.1	79	24	3
June.....	73.8	.08	414.1	451.9	92	28	0
July.....	74.7	.32	430.5	458.6	94	26	0
Total.....	69.7	.84			88.3	78	3
August.....	74	.72	357.6	427.4	84	23	0
September.....	62.7	1.44	288.8	374.	77	18	1
October.....	52.6	1.99	208.8	343.9	61	17	10
Total.....	63.1	4.15			74	58	11
Sum total.....	66.4	4.99			81.2	136	14

¹ Sixty-six miles south of Logan.

DISCUSSION OF IRRIGATION EXPERIMENTS.

The director of the station, Mr. John Widtsoe, under date of November 17. makes the following comments on the season's work:

The sugar content * * * is much lower than the average of the beets grown at the station in the previous years. The beets grown in the irrigation experiments have this season contained from 15 to 18 per cent of sugar. The above varieties were treated as nearly as possible the same as the average beet grower of Utah treats his crop. It is difficult to account for the low per cent of sugar, though I am led to believe from the experiments carried on at the station that the amount of water used and the time of its application has a great influence on the composition of the beet.

It is evident from the various experiments in irrigation previously conducted that an elaborate series of comparative studies should be made to determine, first, the amount of water necessary to produce the maximum weight of crop and content of sugar, and second, the

most favorable periods of its application. It is doubtful whether it is advisable to apply an abundant quantity of water to a beet field as late as September 1, as was the case in the above experiments. The tendency in this case would be to keep the beets growing too long, or perhaps to start a second growth, which would consume much of the sugar already stored.

Another point in connection with the irrigation work should be prominently kept in mind, viz, that the injurious effects of high temperatures as shown in the inferior content of sugar in beets grown far south of the natural habitat may be due rather to premature ripening and the rapid evaporation of water than to the effect of temperature directly. It is difficult to understand how the rise of a few degrees of temperature could so seriously affect the sugar content of the beet simply by reason of increased amount of heat. To me it seems more probable that the deleterious influences of a high temperature are of an indirect rather than a direct nature.

EXPERIMENTS CONDUCTED BY THE WISCONSIN STATION.

CULTURAL DATA.

The field notes in regard to the cultivation of the Austrian Special Kleinwanzlebener beet seed, furnished by Mr. Roscoe H. Shaw, acting chemist of the Madison station, under date of November 7, 1900, are as follows:

The field set apart for sugar-beet work at the Wisconsin experiment station this season was a plat of clay loam consisting of half an acre. This plat had been used for the sugar-beet work in 1898 and for variety tests in 1899. The field was not manured on the northern half in 1898, and not at all in 1899.

The plat was divided into quarters, the middle half receiving a mixed fertilizer consisting of 90 pounds of Star phosphate (dissolved bone), 90 pounds of sulphate of potassium, and 100 pounds of nitrate of soda. The phosphate was put on first and the potash and half of the nitrate mixed and distributed next. The northern quarter and southern quarter were left unfertilized. The field was disked north and south and then dragged with pulverizer east and west. Eight varieties of beet seed were planted, all of which were received from the Department of Agriculture. The field was planted on May 15. A heavy shower, followed by six days of dry weather, caused the plat to bake so hard that with the exception of the section devoted to Zehringen (Strandes, Germany), of which there was no seed left, it was reharrowed and replanted. From this circumstance, owing to lack of seed, but seven rows of the Austrian Special Kleinwanzlebener were planted; these rows were made 15 inches apart. The second planting was finished May 21.

May 26.—The section not replanted was cultivated with garden wheel hoe. At this time the crust was very hard and beet plants were coming up in spots.

May 31.—No rain to this date and surface of ground was dried out, but beet sprout up in rows.

June 1.—A good rain fell for about an hour.

June 2.—Whole plat cultivated with wheel hoe.

June 4.—Beet plants well up; 1 to 2 inches high.

June 11.—The work of thinning beets was begun. They were thinned so as to

have one strong plant every 8 or 9 inches in the row. At this date the Austrian Special Kleinwanzlebener was rather behind the other varieties in development.

June 19.—The remaining 50 pounds of nitrate, mixed with twice the amount or more of dirt from the field, was sown on the fertilized part.

June 24.—No difference was noticeable between different varieties or between the fertilized or unfertilized parts.

August 4.—Fertilized half of field seemed to be in better condition than the unfertilized.

August 18.—No apparent difference was noticeable between varieties.

October 13.—The beets were harvested; they were rather smaller than average beets and all of the varieties were of comparatively uniform size.

The section of the field devoted exclusively to the Austrian Special Kleinwanzlebener was 192 feet long by 8.75 feet wide, containing 1,680 square feet.

In harvesting beets 50-pound samples from each of the three sections of each variety were taken. In these samples the percentage of shrinkage was determined, and a subsample selected for the sugar determination.

Austrian Special Kleinwanzlebener beets grown and analyzed at the Wisconsin Experiment Station, Madison, Wis.

	Fertilized.	Unfertilized.
Average weight.....pounds..	0.81	0.73
Shrinkage ¹.....per cent..	18.98	19.07
Specific gravity.....	1.0779	1.0753
Sugar in the juice.....per cent..	16.66	15.28
Purity.....	88.53	83.93
Sugar in the beet.....per cent..	15.81	14.52
Total yield:		
Total weight.....pounds..	841.6	542.9
Weight less shrinkage.....do....	681.9	439.4
Sugar.....do....	107.6	63.81

¹ The shrinkage refers to that part of the beet lost in washing and crowning.

Results calculated to the acre are as follows:

	Fertilized.	Unfertilized.
	<i>Tons.</i>	<i>Tons.</i>
Total weight.....	10.91	7.04
Weight less shrinkage.....	8.84	5.7
Sugar.....	1.398	0.83

It is interesting to note the influence of the fertilizer employed. The fertilized sections of the plat yielded almost 4 tons more per acre than the unfertilized, while the percentage of sugar in the fertilized portion was considerably higher than in the unfertilized. Since it would not be quite fair to select either the fertilized or the unfertilized data for purposes of comparison, it has been determined to take the mean of the two as representing the proper data for the comparative work.

The meteorological conditions under which these beets were grown are shown by the following table:

Meteorological data for Madison, Wis., from May to October, 1900.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	<i>Degrees.</i>	<i>Inches.</i>		
May.....	60.6	1.86	6	14
June.....	67.7	3.20	9	7
July.....	70.2	6.91	8	14
Total.....	66.2	11.97	23	35
August.....	75.2	2.72	9	10
September.....	63.6	2.89	6	12
October.....	58.0	4.43	10	14
Total.....	65.6	10.04	25	36
Sum total.....	65.9	22.01	48	71

SUMMARY.

Summary of averages of analytical data, 1900.

	Weight.	Yield per acre.	Sugar in the beet.	Coefficient of purity.
	<i>Ounces.</i>	<i>Tons.</i>	<i>Per cent.</i>	
Raleigh, N. C.....	12.4	1.3	5.2	.....
Lexington, Ky. ¹	9.0	10.0	7.8	69.5
Washington, D. C.....	18.5	15.0	8.3	69.1
Lafayette, Ind.....	4.9	.....	9.9	83.0
Ames, Iowa.....	13.0	.....	11.7	76.9
Logan, Utah.....	.....	18.9	12.1	84.2
Agricultural College, Mich.....	12.0	15.8	13.1	80.0
North Judson, Ind.....	15.2	.....	13.7	89.5
Ithaca, N. Y.....	18.0	15.0	14.0	81.9
Madison, Wis. ²	12.3	9.0	15.2	86.2
Geneva, N. Y. ³	16.1	.....	15.5	83.9

¹ Average of data obtained at Washington and at Lexington.

² Average of data for fertilized and unfertilized plats.

³ Average of data obtained at Washington and at Geneva.

Summary of meteorological data, May to October, 1900.

	Temperature.	Precipitation.	Clear days.	Cloudy days.	Sunshine.
	<i>Degrees.</i>	<i>Inches.</i>			<i>Per cent.</i>
Raleigh, N. C.....	74.9	24.8	100	24	73.9
Lexington, Ky.....	72.1	16.9	68	28	74.7
Washington, D. C.....	71.7	24.5	96	48	64.5
Lafayette, Ind. ¹	69.8	30.5	64	53	64.7
Ames, Iowa ²	68.2	36.3	89	11	62.7
Logan, Utah ³	63.0	6.2	138	28	81.2
Agricultural College, Mich. ⁴	64.5	17.5	81	40	59.2
North Judson, Ind.....	68.3	20.2	(⁵)	(⁵)	(⁵)
Ithaca, N. Y.....	65.1	13.8	50	68	69.2
Madison, Wis.....	65.9	22.0	48	71	.....
Geneva, N. Y. ⁶	66.4	16.3	(⁷)	(⁷)	(⁷)
	66.0	15.0	.....	.....	.....

¹ Approximate data observed at Indianapolis.

⁴ Approximate data observed at Detroit, Mich.

² Approximate data observed at Des Moines.

⁵ See Lafayette.

³ Approximate data observed at Salt Lake City.

⁶ Data for Lyons, N. Y., used.

⁷ See Ithaca.

Summary of geodetic data for experiment stations.

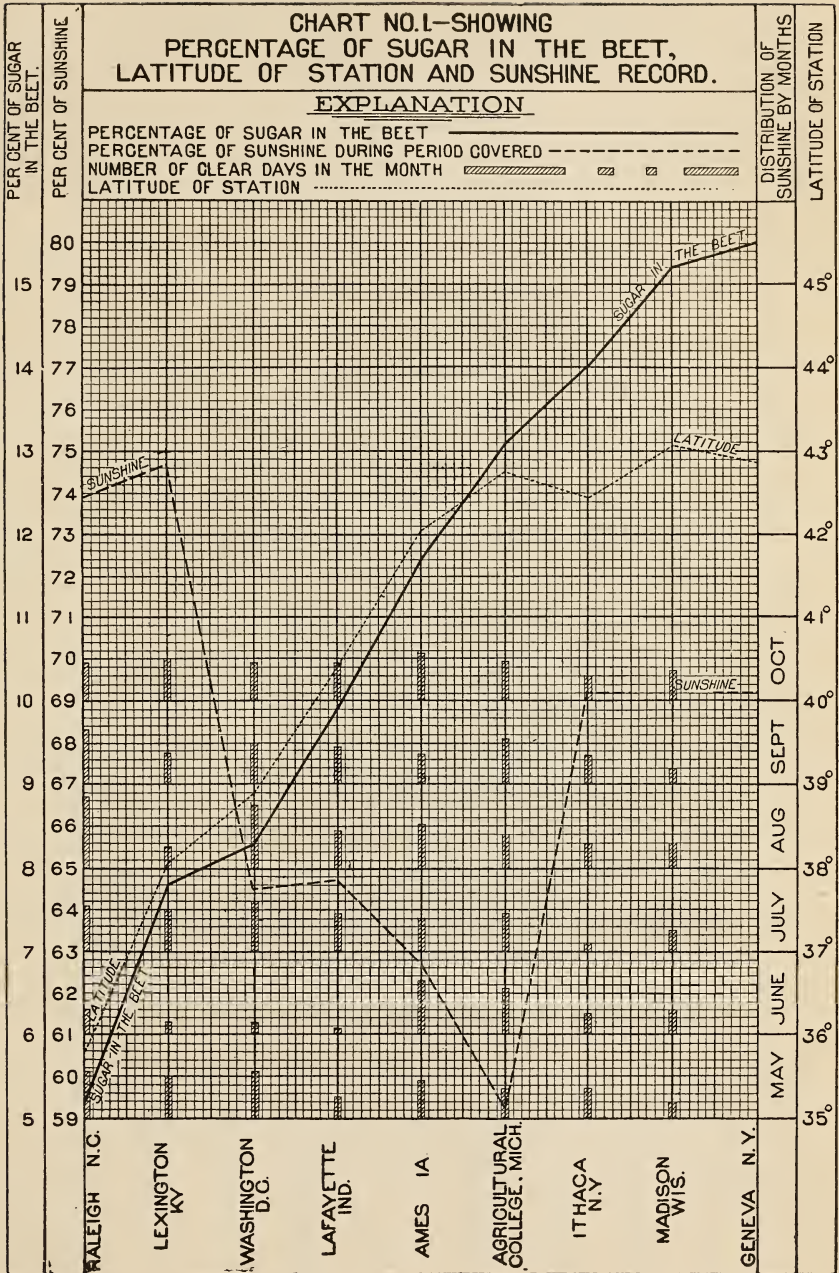
	Average length of day.		Latitude.			Altitude.
	<i>H.</i>	<i>M.</i>	<i>°</i>	<i>'</i>	<i>"</i>	<i>Feet.</i>
Raleigh, N. C	14	7	35	48	00	363
Lexington, Ky.	14	18	38	02	25	979
Washington, D. C	14	23	38	53	23	37.5
Lafayette, Ind	14	30	40	23	00	542
Ames, Iowa	14	38	42	02	00	917
Logan, Utah	14	37	41	44	00	4,506
Agricultural College, Mich ¹	14	42	42	45	00	847
North Judson, Ind.....	14	34	41	11	00	695
Ithaca, N. Y	14	41	42	27	00	810
Madison, Wis	14	44	43	04	36	955
Geneva, N. Y	14	44	42	53	00	453

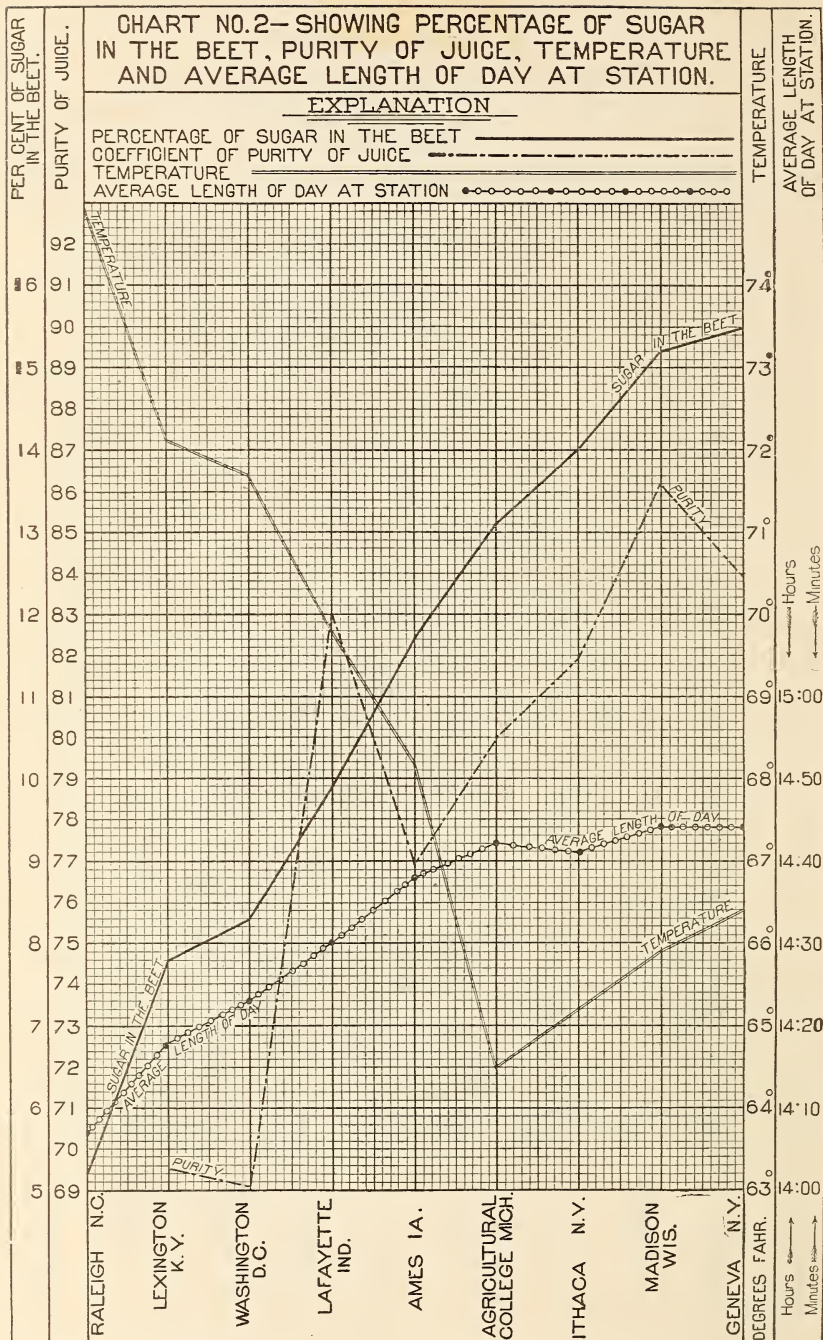
¹ Determinations for Lansing, Mich.

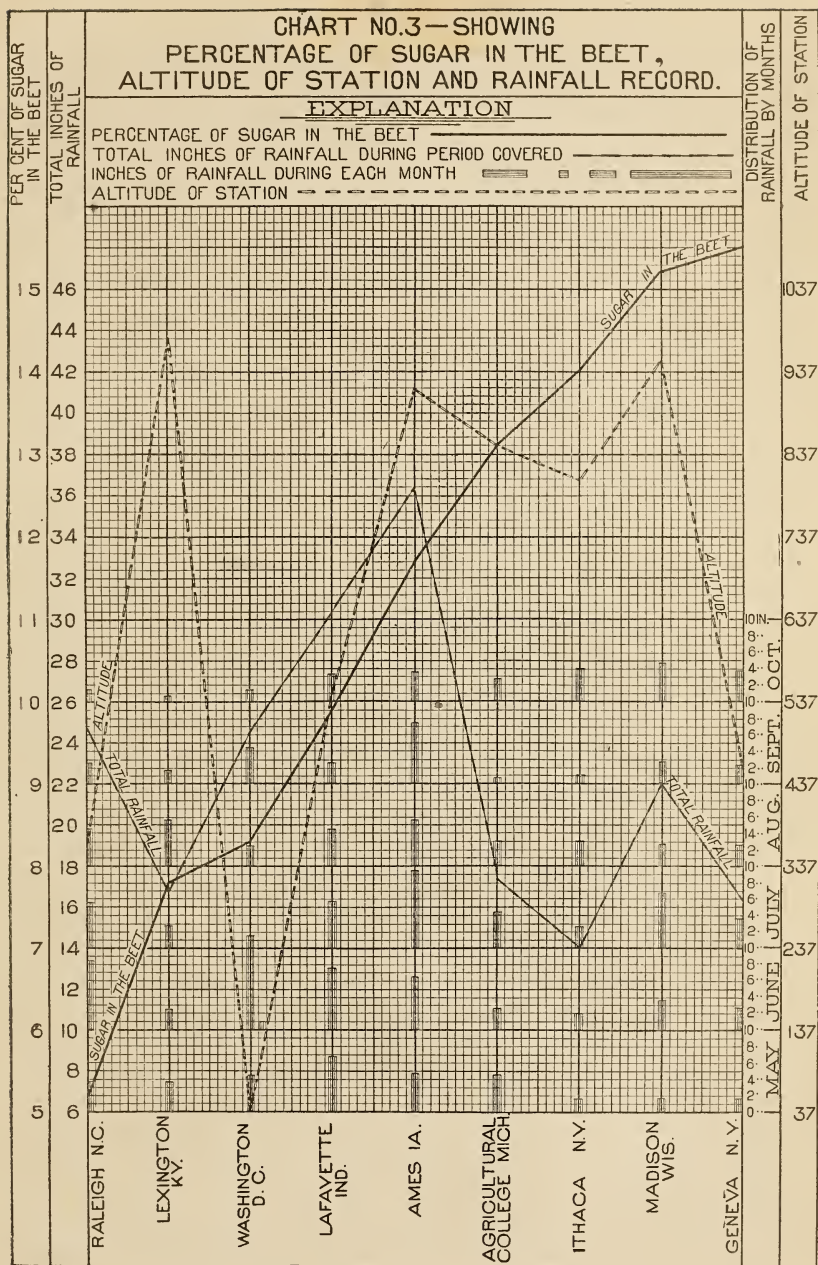
CHART NO. 1—SHOWING
PERCENTAGE OF SUGAR IN THE BEET,
LATITUDE OF STATION AND SUNSHINE RECORD.

EXPLANATION

PERCENTAGE OF SUGAR IN THE BEET —————
PERCENTAGE OF SUNSHINE DURING PERIOD COVERED - - - - -
NUMBER OF CLEAR DAYS IN THE MONTH // // // // //
LATITUDE OF STATION
LATITUDE OF STATION







CONCLUSIONS.

The conclusions which are deduced from a study of the preceding data and the graphic charts, based as they are upon the observations of a single year, will be subject to such correction as may be indicated by the results of subsequent studies.

On Chart No. 1 are platted the percentage of sugar in the beet, the latitude of the station, and the hours of sunshine. The curve representing the latitude and the curve representing the sugar in the beet are evidently more nearly related to each other than the curves representing any other figures in any other one of the three charts. It will be seen that there is a very close agreement between the latitude curve and the percentage of sugar curve. High sugar and high latitude run very evenly together. The actual hours of sunshine do not appear to have much influence upon the sugar content, or perhaps it would be better to say that the curves do not coincide even approximately.

It is evident that the elements of sunlight, which are active in promoting the action of the chlorophyll cells in the formation of sugar, do not depend upon the direct rays of the sun. The diffused light coming through the clouds is apparently quite as effective as the direct light. The highest percentage of sunshine found in any of the stations plotted was at Lexington, Ky., reaching nearly 75 per cent of the possible hours of sunlight. The lowest percentage of direct sunshine was found at Agricultural College, Mich., being 59.2 per cent. Interesting data are also given in connection with the total sunshine by the boxed lines showing approximately the distribution of the sunshine in the various months, i. e., the number of clear days.¹ In order to show the complete relation, however, this line must be taken in connection with the number of cloudy and partly cloudy days. A striking illustration of this is shown by the data at Lexington, Ky., for June. During this month there were four clear days, and therefore the boxed line for June in the Lexington column is very short. The number of cloudy days was only seven, and there were nineteen days partly cloudy. In the study of the chart, therefore, it must be remembered in all cases that the boxed lines represent only the number of perfectly clear days. In Chart No. 1, therefore, it is seen that Raleigh, N. C., and Washington, D. C., have the largest number of clear days, while Madison, Wis., Ithaca, N. Y., Lafayette, Ind., and Lexington, Ky., are types of stations where the number of clear days was relatively small. No record was made for the station of Geneva, but the data may be assumed to be practically the same as for Ithaca. The value of the lines showing

¹ A clear day is one having on the average not more than three-tenths of the sky covered by clouds; a partly cloudy day is one having on the average from four to seven-tenths (inclusive) of the sky covered by clouds; and a cloudy day is one on which the sky is overcast or at least eight-tenths covered by clouds.—U. S. Weather Bureau.

the distribution of sunshine is therefore less than if all the elements entering into the sunshine could be combined into a single curve.

Chart No. 2 shows the curve for the sugar in the beet, the purity of the juice, the temperature, and the average length of the day. In this chart we have a remarkable illustration of the influence of high temperature upon sugar content. The two curves make almost an X-shaped figure. Low sugar and high temperature evidently go together. The highest temperature record for the summer was at Raleigh, N. C., and the lowest at Agricultural College, Mich. The temperature curve could also be very profitably compared with the latitude curve on Chart No. 1. It would form, also, an X-like figure with that curve. The purity of the juice shows a general tendency to follow the percentage of sugar, though there are many variations from this rule. In general, however, it is shown that the higher the percentage of sugar the higher the purity.

The curve showing the average length of day from sunrise to sunset has a direct relation also to the content of sugar in the beet. The shorter the day the lower the content of sugar and the longer the day the higher the content of sugar. This variation is doubtless partly due to the longer action of the sun's rays either directly or diffused through the clouds upon the sugar producing cells of the beet.

In Chart No. 3 are platted the curves showing the percentage of sugar in the beet, the total rainfall, the distribution of rainfall by months, and the altitude of the station above the sea level. The general influence of altitude, as is well known, is to lower the temperature for a given latitude. In other words, the altitude to a certain extent becomes a function of the latitude curve, and it would probably be advisable in some way to combine the two into a single curve. The highest altitude of the experimental stations collaborating (exclusive of Logan, Utah, which is not included in the charts) is at Lexington, Ky., namely, 979 feet; the lowest (sea level) at Washington. Other notably high stations are at Ames, Iowa, and Madison, Wis., and other notably low stations are at Raleigh, N. C., and Geneva, N. Y.

A more important relation to sugar content is shown by the rainfall, especially in its distribution. The total amount of rainfall, it is evident, has less influence on the sugar content than its even distribution during the growing months, providing the rain is sufficient for the growing crop. The greatest rainfall shown by any of the stations was at Ames, Iowa, and the lowest at Ithaca, N. Y. The rain at Ames was evidently far in excess of the requirements of the growing crop. The Washington rainfall was quite sufficient in quantity, but it was extremely uneven in distribution. For instance, during the month of June about 11 inches of water fell in Washington, while in July and August, when water was most needed, the amount was only about 1 and 2 inches, respectively. A very even distribution of rainfall is shown in the station at Geneva,

N. Y., while the quantity was relatively small. The distribution of the rainfall, also, at Ithaca was somewhat even, but there was a slight excess in October at a time when it would be injurious to the beet in the way of inducing a second growth. On the other hand, the September rainfall at Ithaca was small, thus favoring the ripening of the beet. The ideal conditions for the growth of the beet are an even distribution of the rainfall of from 3 to 4 inches during the months of May, June, July, and August, and a reduction of the rainfall for September and October.

The above conclusions, derived from these studies of a year, are quite in harmony with the theories which already prevail in regard to the effect of seasonal influences upon the sugar content of the beet. There are many problems, however, presented by the data which offer an inviting field of study. Chief among these is the suggestion, which has already been made in a previous part of this bulletin, that the high temperature line which seems to be so disastrous in its effects upon the sugar content of the beet may not produce all these ill effects directly as the result of the high temperature, but indirectly in the effect produced upon the moisture in the soil, the arrest of growth by dry weather, the inducement of a second growth on the accession of rains following a drought, and in other indirect ways. The study of this problem would best be carried on in an irrigated arid region where the temperature is high during the growing months and where the distribution of water on an experimental plat could be absolutely controlled. Other new problems of interest are also presented in studying the effects of direct and indirect sunshine and the distribution of the hours of direct sunshine compared with indirect and with partly cloudy weather.

In the study of these problems so far we are indebted to the cordial cooperation of the Weather Bureau and experiment stations, and in the further elaboration of them we rely on the promise of the continuance of this aid. It is certain that environment, of which meteorological conditions form the chief component, have a most marked influence on the chemical composition of crops, and without the assistance of the Weather Bureau it would be difficult to properly study the extent of the changes produced.

The analytical work in connection with these investigations was conducted by Dr. G. L. Spencer, in charge of the sugar laboratory of this Bureau, to whom I am indebted for many suggestions in the preparation of this bulletin.

